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Freeway Traffic and Air Quality in the South Coast Air Basin: Diurnal Patterns by Day of Week

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Introduction

In support of our ongoing analysis of weekday-weekend differences in air pollution, we continued our analyses of traffic data for freeways in the South Coast Air Basin during the summer of 1997. Some evidence suggests that day-of-week differences in emissions may be dominated by differences in on-road vehicle activity; therefore, an understanding of hourly traffic patterns by day-of-week (DOW) is an important objective. Although traffic data for surface streets are still quite limited, the methods applied to the freeway data have been refined and are now stable. We hope that the results shown here for selected regions of the South Coast Air Basin will be useful in formulating further studies.

Data

Traffic managers in Los Angeles and Orange Counties use data from a CALTRANS network of sensors that gather traffic data continuously. The purpose of this network is to support a rapid response to accidents and other events that impede the smooth flow of traffic on the region's freeways. Data are collected in 30-second increments but the 30-second data are not archived routinely. By special arrangement, however, all of the 30-second data during the recent South Coast Ozone Study (SCOS97 - June 15 through October 10, 1997) were archived for further analysis.

Some desirable data, such as vehicle type (car vs. 18-wheeler), vehicle speed, and surface street traffic are not included in the database used here. Limited data on surface street traffic is becoming available, which is encouraging because approximately one half of the total vehicle miles traveled (VMT) is on surface streets. Despite these limitations, the analysis of the freeway data is expected to help in comparisons of hourly traffic volumes by DOW throughout Los Angeles and Orange Counties.

We intend to analyze six (6) regions within the South Coast Air Basin. These regions or domains are related to seven (7) air-quality monitoring sites. The six regions are called the Lynwood domain, the Anaheim domain, the Azusa domain, the Los Angeles CBD domain, the Reseda domain, and the Pico Rivera domain.

At this time, we have completed the analysis for the Lynwood domain and the Anaheim domain. The Lynwood domain is a 40 square mile region, from North Long

Beach in the South to Lynwood in the North. Freeway I-710 runs approximately down the north-south axis of this region. This region includes approximately 90 sites that collect vehicle counts. Among these sites, we used traffic counts from 37 pairs of sites. The Lynwood domain includes two air-quality monitoring sites, one at Lynwood and the other at North Long Beach.

The Anaheim domain is approximately 12 square miles, comprising a triangle bounded by I-5, SR-91, and SR-57. This region includes 36 sites that collect vehicle counts. Of these, we used the traffic counts from eight pairs of sites with validated data. The Anaheim domain includes the air-quality monitoring site at Anaheim.

Methodology

In each of the regions we analyzed, counters (sites) were selected in pairs that cover both sides of a freeway. In this way, the traffic on both sides at different times of the day is represented appropriately. For example, sites on the "inbound" and "outbound" sides of the freeway are balanced.

For the Lynwood domain, we relied on the QA procedure applied by Dr. Niemeir and her co-workers at the University of California at Davis. The criteria are reported in her documentation. For the remaining regions, the following QA procedure was used to validate the data selected for these analyses. In each case, the criteria are applied to data by lane of the freeway and by DOW and were applied in the sequence given below:

- Counts were aggregated to 10-minute intervals
- Zero counts were invalid (set to "missing")
- Counts greater than 600 were invalid (set to "missing")
- Data were invalid for a whole day if the day's maximum 10-minute count < 20
- Data failing a comparison to a median value were invalid
- If a 10-minute period had less than 4 valid days (so far) it's average value was invalid
- If a lane had any invalid average for a 10-minute period, the lane was invalid always

Inductive loop counters typically yield highly accurate counts based on ground truth comparisons (FHWA-RD-95-100 Volume 1: Final Report). When they fail, however, the dominant failure mode is to cease detecting vehicles entirely and report "zero" traffic. Unfortunately, a zero count is entirely reasonable for a single 30-second interval, so zeroes cannot be excluded at the 30-second level. Therefore, the 30-second counts were aggregated for 10-minute periods. A zero count is not reasonable for a 10-minute period, so these zeroes were invalidated.

Valid traffic counts greater than 30 vehicles in 30 seconds can be valid (personal check on a Sacramento freeway overpass). However, such flow rates cannot be sustained for very long. Therefore, 10-minute counts greater than 600 were invalidated.

The comparisons of 10-minute counts to their corresponding median value (same DOW and same period) helped eliminate 10-minute counts based on a mix of valid and

invalid 30-second counts. Any particular 10-minute interval for a specific DOW is very unlikely to be affected by more than one invalid aggregate count. Therefore, the median of the valid (non-zero) observations should represent the valid data well. If a 10-minute count differed from its respective median by more than 2/3 of the median value, that 10-minute count was invalid.

Using the preceding criteria, a valid average count for each 10-minute period for each DOW was based on at least 4 days of data. Although this is a small sample size for many situations, in this case it seems to be satisfactory. This is because the valid counts for the same lane, 10-minute period, and DOW combination are very similar to one another (the variability is small).

Keeping the valid lanes at a site allowed these lanes to represent the site effectively. As a final step, we included pairs of sites in the analysis only if they had the same number of valid lanes. This approach is suitable for comparing traffic patterns by DOW in relative terms, but it undercounts the actual volume of traffic due to the missing lanes. For our purposes, however, the relative activity by DOW is satisfactory.

Results

Traffic counts for the Lynwood and Anaheim domains are shown in the figures below. Figure 1 shows the aggregate counts by hour and DOW for the Lynwood domain based on the selected sites, while Figure 7 shows the corresponding counts for the Anaheim domain. The traffic counts are shown again in Figure 2 and Figure 8, but this time they are determined relative to the midweek average (Tuesday through Thursday) for the corresponding hour of the day.

Air quality data for the ozone precursors, VOC and NOx, are shown in the companion figures for the two domains. In each case, the diurnal trends are shown by hour and DOW. As with the traffic data, the data are presented in the original units and as relative values with respect to the midweek average for the corresponding hour of the day.

Discussion

A few observations are suitable for discussion at this point. First, the traffic volume on freeways is generally lowest on Sunday for almost all hours of the day in both the Lynwood and Anaheim domains. Saturday tends to have lower volumes of traffic during most hours of the day compared to any weekday.

The diurnal patterns for traffic are much “smoother” than their air quality counterparts. This is almost certainly caused by the additional ‘meteorological” component of variation that affects the air quality measurements. Although human behavior is affected by meteorological conditions, we are much less affected that are the concentrations of air pollutants. We are not half as likely to go to work on Tuesday just because the mixing height is 1600 meters and the wind speed is 10 mph instead of 800

meters and 5 mph. Precursor concentrations, on the other hand, are quite likely to be half as high under the first set of conditions compared to the second.

In general, there is an obvious association between the traffic patterns and the air meters and the wind speed is 10 mph quality patterns. It remains to be seen whether the observed patterns are replicated in the other four regions to be analyzed or whether significant regional differences will emerge.

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Figure 1.

Overall Traffic Volume Indicator for Lynwood Domain

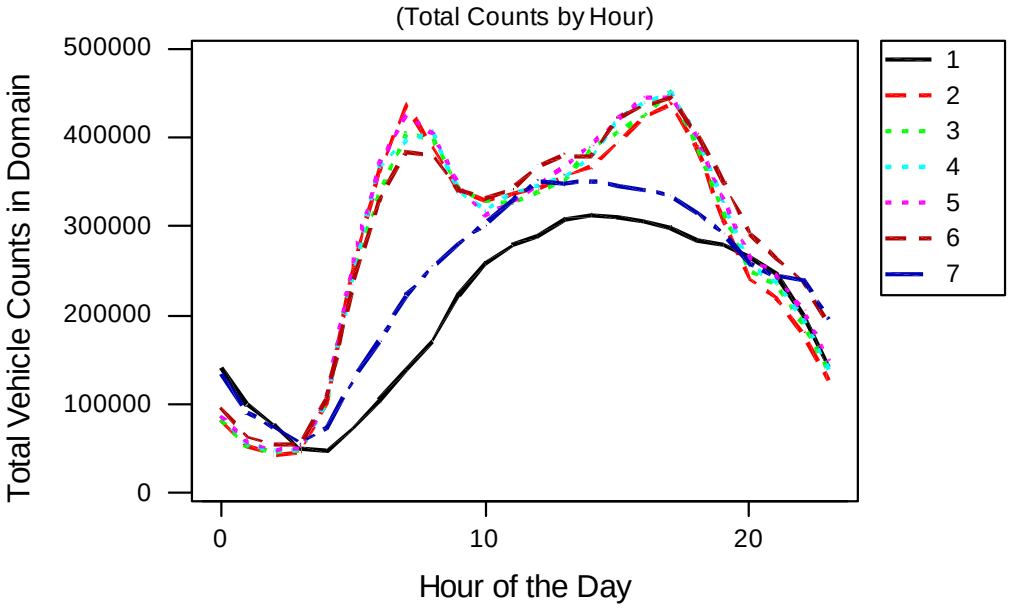

Figure 2.

Traffic Volume Relative to Mid-week for Lynwood Domain

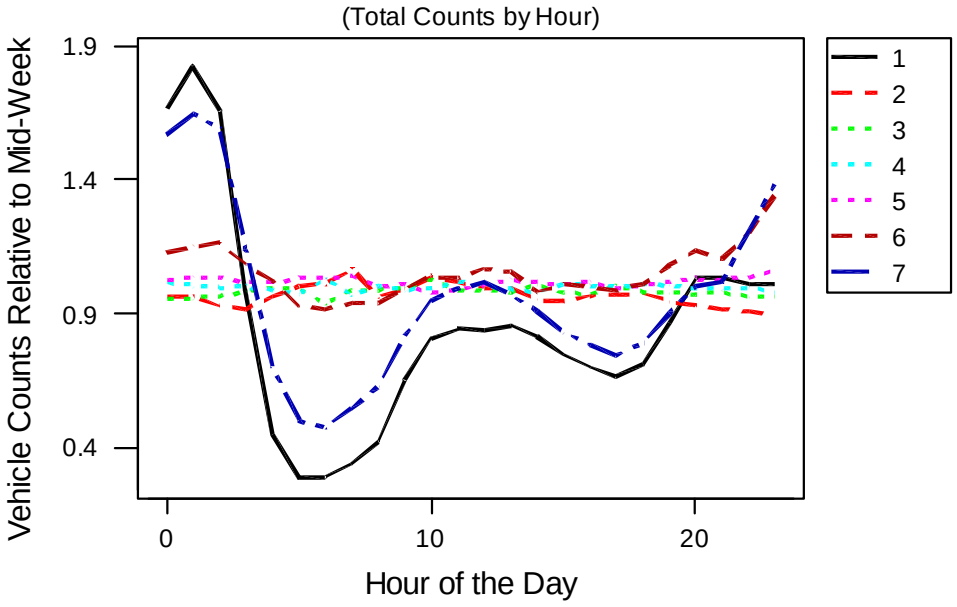

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Figure 3.
Analysis of 1997 Air Quality Data
NOx at Lynwood Monitor by Day of Week

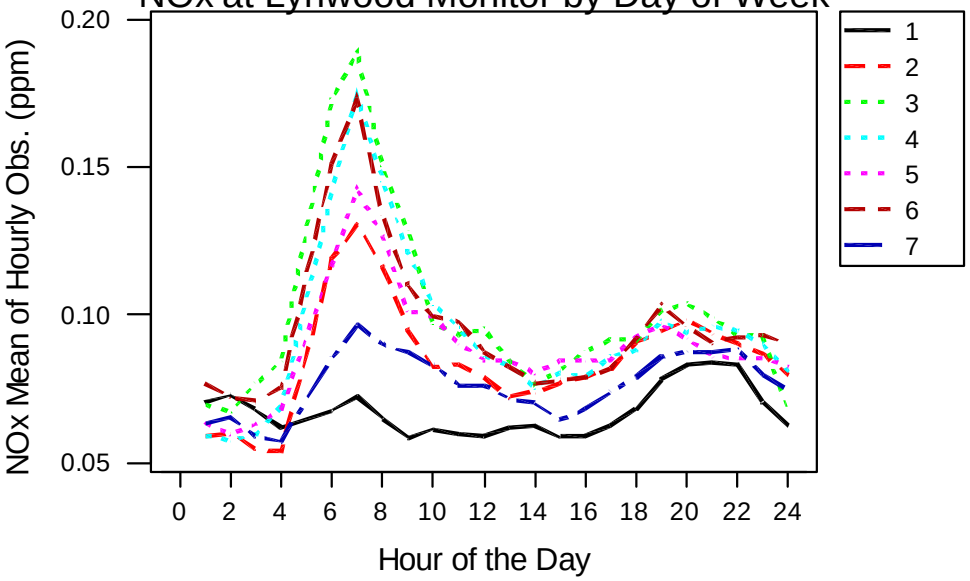

Figure 4.
Analysis of 1997 Air Quality Data
NOx at Lynwood Monitor by Day of Week

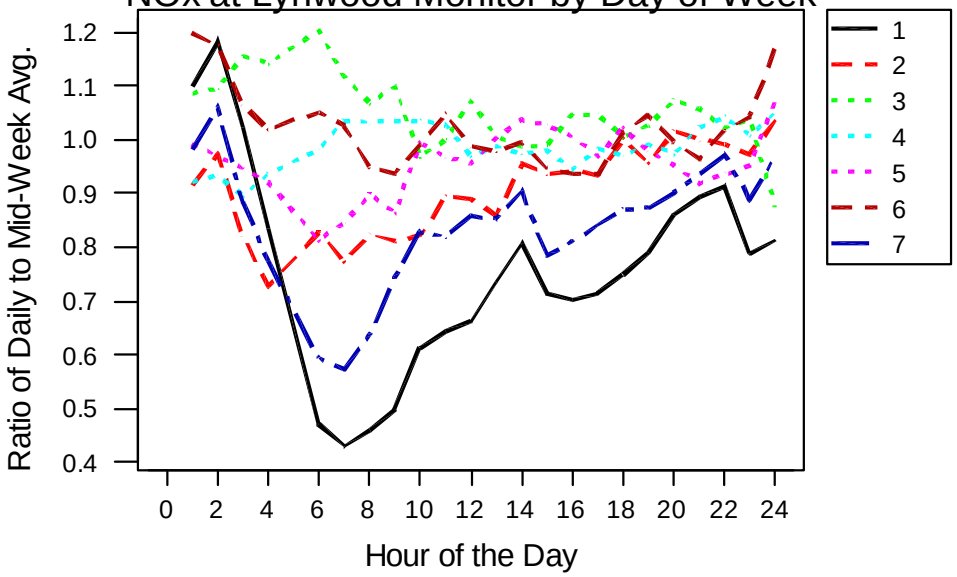

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Figure 5.
Analysis of 1997 Air Quality Data
CO at Lynwood Monitor by Day of Week

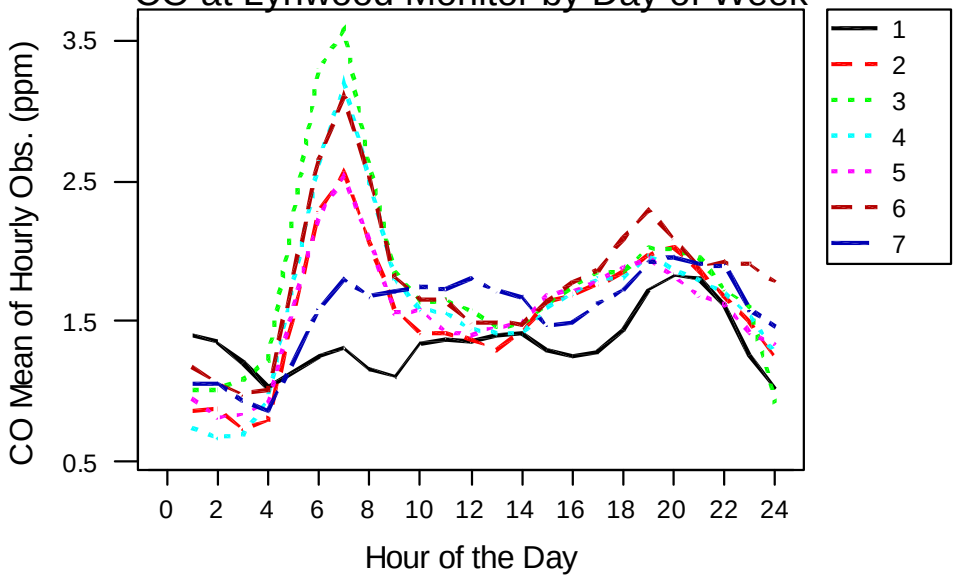

Figure 6.
Analysis of 1997 Air Quality Data
CO at Lynwood Monitor by Day of Week

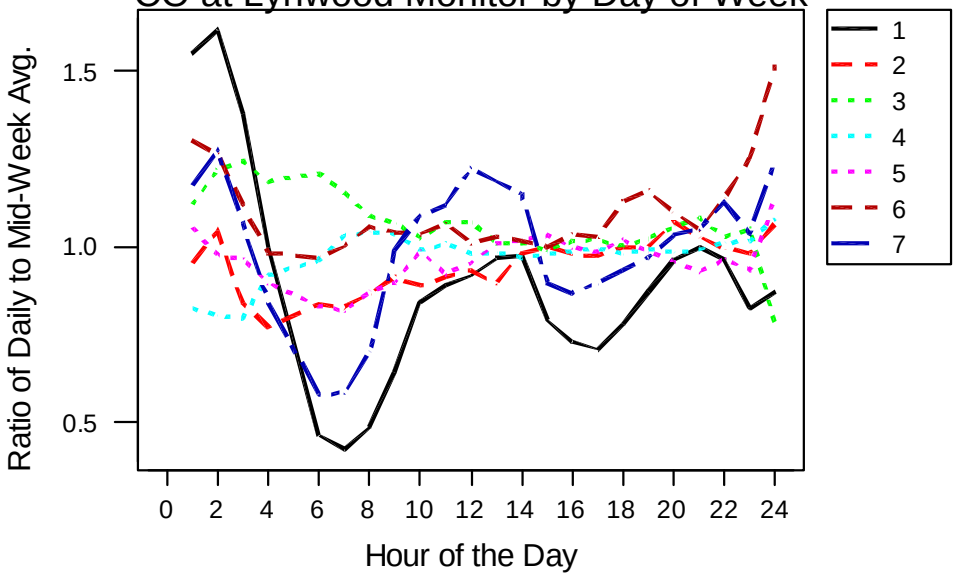

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Figure 7.
Analysis of Freeway Vehicle Counts
Anaheim Domain by Day of Week

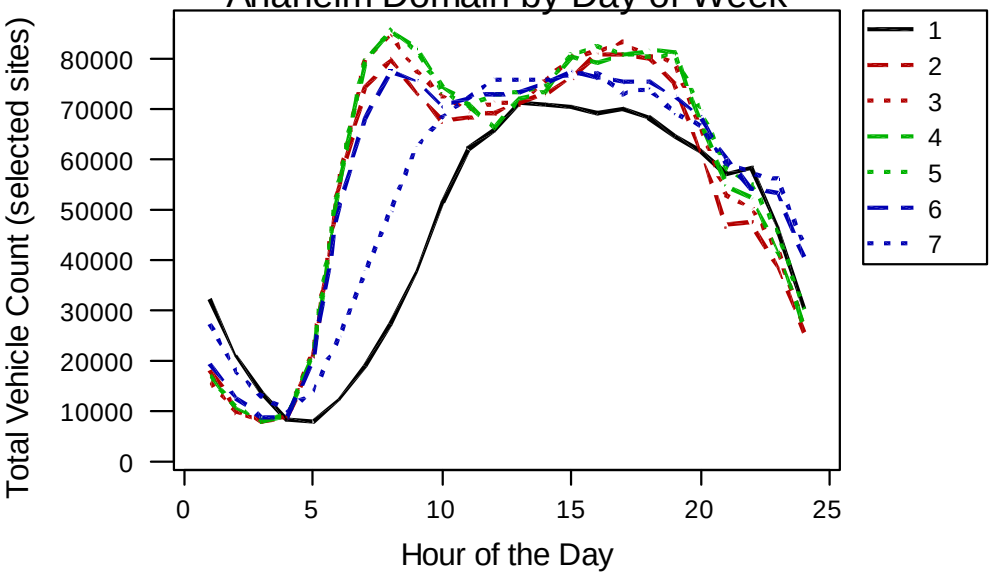

Figure 8.
Analysis of Freeway Vehicle Counts
Anaheim Domain by Day of Week

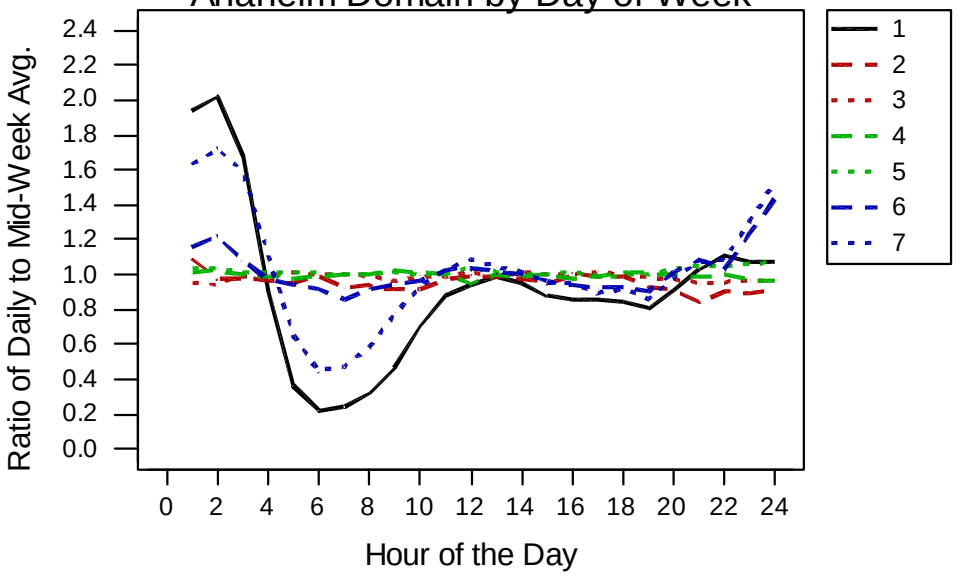

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Figure 9.

Analysis of 1997 Air Quality Data

NOx at Anaheim Monitor by Day of Week

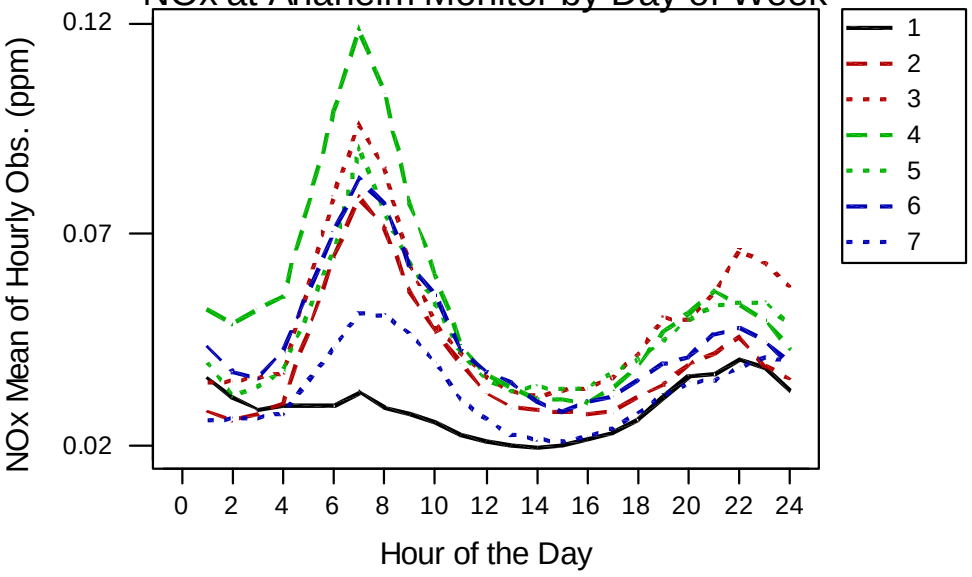

Figure 10.

Analysis of 1997 Air Quality Data

NOx at Anaheim Monitor by Day of Week

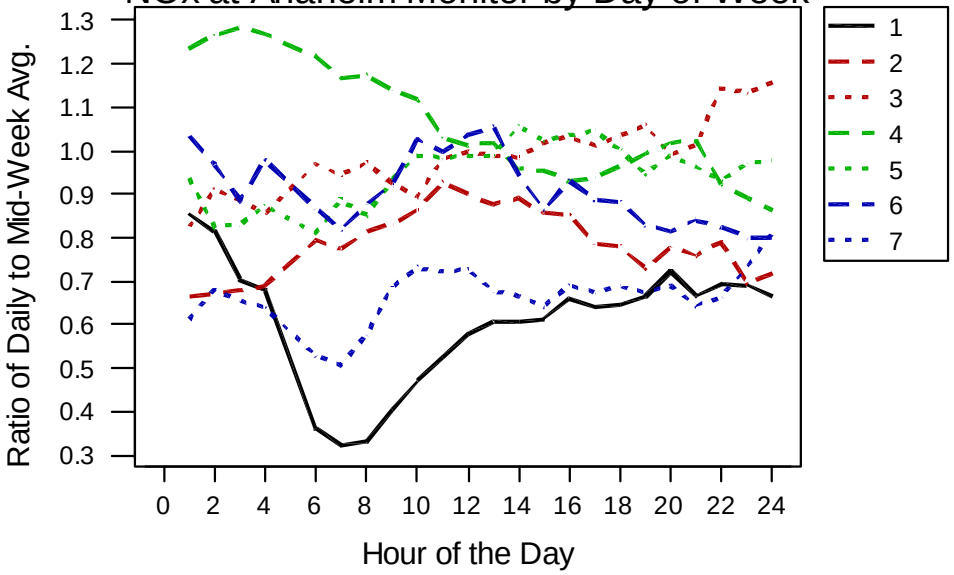

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Figure 11.
Analysis of 1997 Air Quality Data
CO at Anaheim Monitor by Day of Week

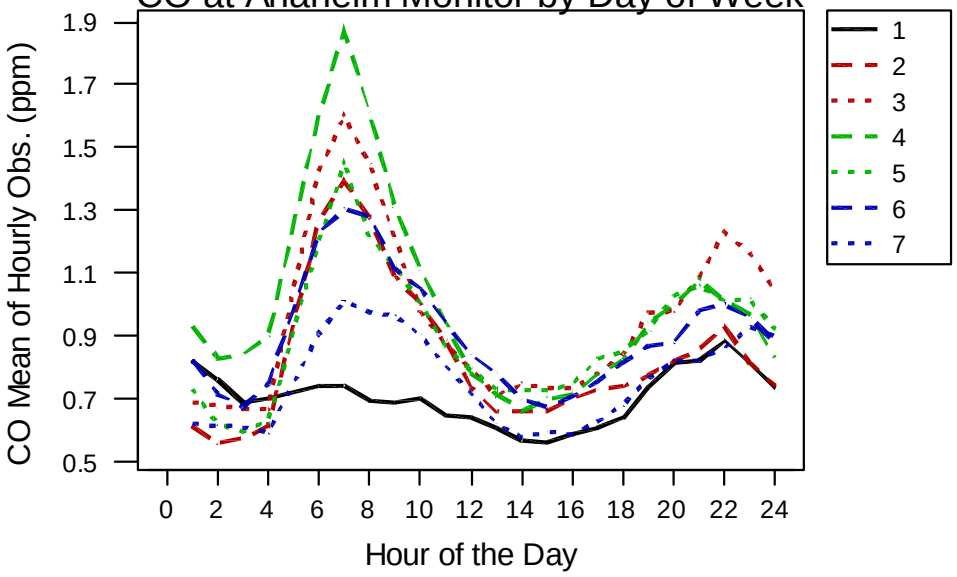

Figure 12.
Analysis of 1997 Air Quality Data
CO at Anaheim Monitor by Day of Week